The Landscape of Lake Sevan (Armenia) during the Urartian Period

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For years, the "Istituto per gli Studi Micenei ed Egeo-Anatolici" (ISMEA), of the National Research Council (C.N.R.), has carried out an interdisciplinary "Urartu Project", with the aim of reconstructing the Urartian civilisation (IX-VII centuries BC). This project included historical, philological, linguistic, bibliographical and archaeological investigations. The borders of the Urartian kingdom, during the period of its largest territorial expansion (the VIII century, BC), encompassed the areas of present eastern Turkey, Armenia and Iranian Azerbadjan (Fig. 1). Since 1994, the ISMEA has organised four campaigns in Armenia, in collaboration with the Institute of Archaeology and Ethnography, of the National Academy of Sciences, in the Republic of Armenia (IANAS), on Erevan.

The main aim of these surveys was the study of the region of Lake Sevan, as the north-eastern periphery of the Urartian state and the fortified frontier, against invasions of Cimmerian and Scythian populations. The Urartian conquest, of the Lake Sevan region, started around 782, BC, when Argishti I led the first expedition into this area.

The ISMEA- IANAS investigation began in the provinces (*rajon*) of Vardenis and Martuni, to south of Lake Sevan. About 70 "sites", including fortresses, forts, settlements, necropolis and tombs (ranging from the Early Bronze Age to the Medieval period), have been identified, examined and documented: their geographical coordinates were recorded with a GPS satellite navigator.

On the basis of the accomplished archaeological analysis, the following conclusions can be inferred:

I) the Urartian fortresses are situated mostly around the Vardenis plain, and along the road joining this plain with the Martuni plain. In the wide Vardenis plain, there exists a noteworthy gold mine, in the neighbourhood of the village of *Sodk*. These fortresses stand at a relatively low elevation (1900 to 2000 m, a.s.l.), at the foot of the hills, facing Lake Sevan;

II) the settlements' arrangement and the landscape control reached their height, during the Early Iron Age (1200 to 750, BC): e.g., all the Urartian fortresses also exhibit Iron Age pottery;

III) the Iron Age fortresses are placed as clusters, including 3 or 4 of them, placed with a few km distance, between one another. Within each cluster, there exists a fortress, much larger than the others, functioning as a "*central place*". They are located above 2200, a.s.l..

Therefore, the Urartian people were not interested in directly controlling the mountain valleys, but, probably, only in collecting taxes.

In order to reconstruct the setting of the landscape, where the Urartian communities located their settlements, research, based on the analysis of thematic maps derived from a Digital Elevation Model (*DEM*), was conducted, with the aim of identifying the reasons for the choice of site locations. *DEM* is a digital representation of terrain relief, describing the geometry of the Earth's surface, or a portion of it (Tempfli and Tuladhar, 1991). As such, it consists of a set of coordinates of points, which are obtained by sampling the surface, and the use of an algorithm, which defines an uninterrupted surface, using this set of coordinates.

The creation of the DEM, covering the study area, began by digitizing the contour lines, with a 100 m contour interval, between 1900 m (Lake Sevan coast level) and 3800 m, a.s.l., from a mosaic of two contiguous topographic sheets, at 1:100,000 scale. The obtained, vector data set was then utilized to set up a DEM, by applying classical interpolation techniques. This DEM, was the base for creating two DEMs, with pixel resolutions of 50 m and 20 m, the former being useful for regional scale analysis, and the latter, for local landscape studies. The two DEMs were geo-referenced with respect to a UTM projection grid, by taking into account different Ground Control Points (GCP), chosen along the Lake Sevan coast line, mostly in correspondence to rivers' mouths, and at spot heights, relative to peaks of the volcanoes, located in the study area.

The DEMs were processed to derive digital, *spatial models*, such as *shaded relief, slope, and aspect* maps, which investigated surface, morphological differences, expressed as discontinuities in topography, in slope, and in relief.

The *shaded relief* map is an interesting product, useful to portray relief differences in hilly and mountainous areas; its principle is based on a model of what the terrain might look like, as illuminated from a lighting source, seated at any position above the horizon. The result appears similar to an aerial photograph, or satellite image, because depicted, using grey scales, but, different from the data sets, it does not display terrain covers, but only digitized land surfaces.

The shaded relief, as far as the southern Lake Sevan region is concerned, was created by choosing a lighting source, at an angle of 30° above the horizon, in the south-west (fig. 2). By combining this shaded relief map with the original elevation information, coded in colour, another thematic map, which provided a synoptic view, at a zenith angle of the landscape, was obtained: the represented colours spanned from blue, 1900 m (Lake Sevan level and data-lacking area), to magenta, 3800 m, a.s.l. (fig. 3).

This colour-coded image was then visualized, by means of an oblique perspective representation (Sauter, *et al.*, 1989) with a view from the North (fig. 4). Oblique perspective views are other interesting products, obtained by processing a DEM: they constitute a valuable reference tool for visual correlation, between spectral/spatial information from field observations, and the information presented on maps. For instance, the perspective views allow geologists to get better insight into geological and geomorphic relationships. To derive these pictures, it was necessary to choose a perspective, from any point in the 3D space, above the horizon plane.

The other geomorphometric, digital data sets, which were extracted from the DEM, were: *slope*, defined as the rate of change of elevation, and *aspect*, representing the direction in which a slope faced. Both spatial models were then displayed, together with the cited, shaded relief, within a single picture, showing the shaded relief in different coloured hues, defining aspect values, and with colour saturation intervals, corresponding to slope angles (fig. 5). This digital product was obtained, by applying a classical, mutual colour transformation from the *Red-Green-Blue* (RGB) coordinates space to the *Intensity-Hue-Saturation* (IHS) system. IHS system had the advantage, with respect to the RGB space, that the two input data sets could be differently combined, by mathematical arrangement, to attain the desired colour result (K. Edwards and P.A. Davis, 1994).

In the case of the Lake Sevan area, the final RGB colour composite was obtained, by using the shading map (*Intensity*), the aspect (*Hue*), and the slope (*Saturation*) as input data sets, and then performing the subsequent transformation. This choice reflects the nature of the three spatial models; in fact, the shading map, like the *Intensity,* represents a brightness image; the aspect, like the *Hue,* exhibits angle values, ranging between 0° and 360°, with a cyclic pattern like a wheel; the slope, by means of *Saturation,* emphasizes the topographic change gradient.

The same methodology was applied, to merge the shaded relief with a rasterized, geological map of the Lake Sevan region, compiled by the Armenian geologist, Yuri Sayadyan, using a 1:100,000 base scale. The two data sets, before being merged, were co-registered, keeping as reference, the above-mentioned, UTM projection grid. The *RGB* to *IHS* spaces transformation was carried out, according to the following steps: i) calculate a pixel's *IHS* values from the corresponding *RGB* values, exhibited in the colour-coded geological map, ii) substitute for that intensity value, the one for the relative pixel, in the shaded relief map, iii) recalculate the pixel's new *RGB* values from its changed *IHS* values. The output map depicted not only the landscape morphology, but the colour hues also kept pointing out different lithologies.

Once the described digital maps were created, a main goal of the archaeological analysis was the interpretation of the settlement location choices, with respect to the surrounding landscape. The first step was the overlapping of the Urartian sites on the thematic maps, in order to reconstruct the eastward pathway of the Urartian conquest, followed by that of the Iron Age sites (fortresses, forts, open and fortified settlements), to analyze local landscape control. This superimposition was possible, because during the field surveys, each site was described by a form, pointing out, also, its geographical coordinates, recorded with a GPS. In order to overlap the archaeological sites, onto the UTM geo-referenced maps, a transformation from *Latitude/Longitude* to *Y/X UTM* coordinates systems was carried out, by applying classical, cartographic formulas (Thomas, 1952).

Moreover, the mutual distance between each Urartian site was calculated, in order to understand the reasons for the choice of their location, which could be connected to the problem of controlling either the main road, parallel to the lake coastline, or the mountain land, still inhabited by the pre-existing populations.

The distances were computed on the basis of a *Fortran* routine, implemented by the authors, presuming an ellipsoid model of the Earth, with a major axis, *REQ*, and a minor axis, *REP*, with the locations of the two sites, ploted in spherical coordinates, latitude (*LAT1, LAT2*) and longitude(*LON1, LON2*) (see Table 1).

Table 1

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LATAVG= (LAT1+LAT2)/2.
 A=1.0/297.3
 REP=REQ/(1+A)
 RFL=REQ/REP
 RFL2=RFL*RFL
R=REQ/(SQRT(RFL2+(1.0-RFL2)*COS(LATAVG)**2))
CK=ACOS (SIN (LAT1) *SIN (LAT2)+COS (LAT1) *COS (LAT2) *COS (LON2-LON1))
DIST=REP*CK
DIST1=R*CK
DIST2=REQ*CK
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In the calculation, three Earth's radii were taken into account, to obtain three different distance values (*DIST, DIST1, DIST2*): the equatorial (*REQ*), the polar (*REP*), and a more general one (*R*), which was derived by considering the average (*LATAVG*) of the two end-point latitudes (*LAT1, LAT2*). Moreover, the elevation differences were ignored, since all sites were located within a unique plain area (1900 to 2000 m., altitude).

Table 2

Sites	*n.*	*Lat (1)*	*Long(1)*	*Lat(2)*	*Long(2)*	*dist(R)*	*dist(REP)*	*dist(REQ)*	*from*	*to*
1	7	40.315	45.681	40.185	45.626	**15163.86**	15134.24	15185.20	Geghamasar	Tsovak1
2	3	40.199	45.867	40.145	45.811	**7592.24**	7577.37	7602.88	Sodk' 1	Jaghats'adzor 1
3	4	40.145	45.811	40.121	45.791	**3205.20**	3198.92	3209.69	Jaghats'adzor 1	Airk 1
4	5	40.121	45.791	40.159	45.730	**6680.01**	6666.92	6689.37	Airk 1	Kol Pal
5	6	40.159	45.730	40.157	45.713	**1455.73**	1452.87	1457.77	Kol Pal	Klor Dar
6	7	40.157	45.713	40.185	45.626	**8072.31**	8056.50	8083.63	Klor Dar	Tsovak 1
7	8	40.185	45.626	40.168	45.592	**3493.70**	3486.86	3498.60	Tsovak 1	K'ari Dur
8	9	40.168	45.592	40.134	45.564	**4393.31**	4384.70	4399.46	K'ari Dur	Karchaghbyur
9	10	40.134	45.564	40.149	45.485	**6863.48**	6850.03	6873.09	Karchaghbyur	Tsovinar 1
10	11	40.149	45.485	40.114	45.455	**4626.01**	4616.94	4632.49	Tsovinar 1	Vardenik 1
11	12	40.114	45.455	40.096	45.354	**8791.35**	8774.11	8803.65	Vardenik 1	Martuni
12	14	40.096	45.354	40.096	45.281	**6259.96**	6247.68	6268.72	Martuni	Al Berd
13	14	40.127	45.258	40.096	45.281	**4029.13**	4021.23	4034.77	Ishan Nahatak	Al Berd
14	15	40.096	45.281	40.192	45.217	**11956.85**	11933.42	11973.60	Al Berd	Kra

The obtained values of distance, for each Urartian site, range between 1.5 and 15.5 km, from the closest site; they are listed in a westward sequence (see Table 2).

Sites, numbered 2 to 15, lie on the main road, running mostly along the southern bank of Lake Sevan. The 2nd site (*Sodk' 1*), the easternmost, is a fortress, built close to a gold mine, at the beginning of a valley, through which there is a pathway to Azerbajian. Site n. 1 (*Geghamasar*), the northernmost, is a fort, probably controlling the whole Lake Sevan plain (which stretches to the south of this fort), and which was probably used only for signalling any possible invasions (about 42 km from the westernmost site, n. 15, the fortress of *Kra*).

Another fortress, exhibiting the function of landscape control, is *Al Berd*, the only Urartian fortress situated at 2000 m of altitude. It is placed at the confluence of the Martuni River valley, which delineates the pathway, through the Selim Pass , towards present Iran.

As shown, up to now, the control of territory, by the Urartians, exhibits a regional scale appearance. The pre-existing populations, instead, were located mostly along a downhill belt, encompassing the Lake Sevan plain, and were grouped, during the late Iron Age, in small clusters of 3 or 4 fortresses, showing a hierarchical setting. To give insight into the corresponding landscape control type, the spatial arrangement of the local sites was visualized, by utilizing, as a base data set, the 20 m-sized DEM. In particular, by looking at the colour-coded DEM (Fig. 6), the south-west side of the studied region, centred around the 2830 m high volcano, was examined, in order to evaluate the geographical distribution of seven, Iron Age fortresses, with respect to the landscape. Among these sites, number 2 exhibits the function of "*central place*" (*Nagharakan*); number 6 (*Sangar*) stands at the second level of hierarchy, while the others function at the same lower level. To better understand the landscape control of these Iron Age sites, two perspective views of the colour-coded DEM were created: the first, with a sight direction from the South, Selim Pass, highlights the landscape, as far as the Armaghan volcano, where the cluster constituted by the sites, numbered 2, 3 and 4, occurs; the second, with a viewing direction from the North (the Lake Sevan south-western coast), depicts the area controlled by the cluster, including (in a North to South sequence) numbers 5, 7, 6, and 1, which looked towards the Urartian main road.

The presented work was a preliminary result of the landscape analysis for the Lake Sevan region, where, together with the analysis of the settlements' location choices and analysis of the surrounding territory, one of the key problems to be investigated was the definition of the lake level during different periods: the water level determined the extent of the peri-lacustrine plain, which, in its turn, biased the number of inhabitants and the possibilities for environmental exploitation. Lake Sevan lies, nowadays, at 1898.06 m a.s.l., in a closed basin, while in the quaternary period, it dried up almost totally; in 1932, the fortress of Tsovinar, the Urartian inscription was located along the shore line; presently it is located at about 17 m above water level.

Between the 6th millennium, BC, and today, four cycles of transgression and regression have been detected; they are related to variations in the water levels of the Van and Urmia lakes, of the Caspian and Aral seas. In the Sevan basin, these flow fluctuations were also due to local volcanic phenomena. This research is based on the integrated analysis, of the mentioned DEMs and SAR (radar) ERS-1 images, acquired from two different years.

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Fig. 1. Sketch map of the Lake Sevan area.

Fig. 2. Shaded relief map of the Lake Sevan region, obtained by illuminating the 50 m-sized DEM, with a south-west view.

Fig. 3. Colour representation of the shaded relief, depicted in fig. 2. Colour hues span from blue, 1900 m (Lake Sevan level and data lacking area), to magenta, 3800 m, a.s.l.

Fig. 4. Perspective view from the North, of the colour-coded shaded relief, shown in fig. 3.

Fig. 5. Shaded relief, as in fig. 2, shown with different colour hues, defining aspect values, and with colour saturation intervals, corresponding to slope angles. Black '+'indicates identified sites.

Fig. 6. Colour representation of the 20 m-sized DEM. The south-west side of the studied region, centred around the 2830 m high volcano, is shown. Seven Iron Age sites are pointed out, as numbered red spots.